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ACCURACY OF WIND DATA OBTAINED BY TRACKING A JIMSPHERE WIND SENSOR SIMULTANEOUSLY WITH TWO FPS-16 RADARS

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ABSTRACT

Thirty dual FPS-16 radar tracks of Jimsphere wind sensors were obtained from Cape Kennedy, Florida, Green River, Utah, and Pt. Mugu, California. The RMS values over two-kilometer layers for wind speed differences, based on wind speeds computed over 50-meter intervals, were calculated for various elevation and azimuth angles and slant ranges. The evaluation was based on data acquired during normal range operations of the FPS-16 radar/Jimsphere system.

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RESEARCH AND DEVELOPMENT OPERATIONS

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SUMMARY

Thirty dual FPS-16 radar tracks of Jimsphere wind sensors were obtained from Cape Kennedy, Florida, Green River, Utah, and Pt. Mugu, California. The RMS values over two-kilometer layers for wind speed differences based on wind speeds computed over 50-meter intervals, ranged from 0.06 to 1.49 m sec^{-1}. Wind speeds from 2 to 68 m sec^{-1} for elevation angles from 85.0 to 5.9 degrees and slant ranges up to 132 km were included in the analysis. Altitudes covered were from surface to about 18 km.

The means of the errors for the zonal, meridional, and scalar wind speeds and vertical rise rate were computed for each location using the available set of RMS errors at each two-kilometer layer. At Cape Kennedy the mean of the RMS errors for seventeen cases ranged from 0.31 to 0.37 m sec^{-1}, while at Green River, the means of the RMS errors for twelve cases were smaller, ranging from 0.17 to 0.21 m sec^{-1}. At Pt. Mugu the RMS error for the one case ranged from 0.24 to 0.36 m sec^{-1}.

I. INTRODUCTION

Balloons are used extensively to determine upper air wind velocity profiles. Detailed wind velocity profile measurements, such as those provided by the FPS-16 radar/Jimsphere method [1], are required for use in space vehicles structure and control studies, astronaut simulation training, prelaunch simulation for space vehicles, and for use in scientific investigations. Figure 1 shows the operational configuration of the Jimsphere balloon* currently used at Cape Kennedy, Florida; Green River, Utah; Pt. Mugu, California; Wallops Station, Virginia; and White Sands Missile Range, New Mexico.

Early experiments (March 1963) [2] of the RMS errors obtained from dual radar tracks (one balloon tracked by two radars) showed values generally less than 0.5 m sec^{-1}. Occasionally, errors due to poor editing appear in the operational radar tracking data which may produce larger RMS errors in the wind data. Contributing to the RMS errors are the condition of the radar, the operator's experience, data editing and reduction

*(ML 632/UM) 6660-115-3686

procedure, and radar-sensor geometry (slant range). It is difficult to theoretically calculate the magnitude of the errors because of the uncertain interrelationship of these and other factors. The data reduction procedure used in this analysis is outlined in reference 2.

The evaluation of the FPS-16 radar/Jimsphere system was based on data acquired during normal range operational use of the tracking radar because, if the system is to be readily usable at various locations, an estimate was desired of the operational system accuracy without imposing constraints relative to special tracking techniques, etc. Special tracking procedures may provide improved accuracy for the system under some conditions.

II. TEST PROGRAM

The practical approach used in this error analysis alleviated the necessity to evaluate the individual system errors and combine them to obtain an overall wind speed error resulting from the tracking, data handling, etc. This was accomplished by independently tracking the same Jimsphere balloon with two radars simultaneously. The resulting wind profiles computed from the tracking data were then compared.

Thirty pairs of profiles, seventeen from Cape Kennedy, Florida, twelve from Green River, Utah, and one from Pt. Mugu, California were obtained. The FPS-16 radar/Jimsphere system consists of a FPS-16 high-precision tracking radar [3] and a super-pressure aerodynamically rough mylar sphere, two meters in diameter [1].

The RMS errors in the computed balloon motions (for all practical purposes, the wind speeds) were determined by assuming that each radar had the same RMS accuracy. Independence is also a necessary assumption, but this is obviously satisfied since the radars operate completely independently. The RMS error, $\sigma_{1,2}$, of the sum or difference of two independent variables (in this case, balloon motion or wind speed) having RMS errors of σ_1 and σ_2 is given by the relation [4]:

$$\sigma_{1,2}^2 = \sigma_1^2 + \sigma_2^2 \ . \tag{1}$$

On the assumption that both radars have the same RMS tracking accuracy, then

$$\sigma_R = 0.707 \ \sigma_1, \sigma_2 \tag{2}$$

where σ_R is the RMS error in observed balloon motions (wind velocity) caused by the tracking accuracy of either radar.

Equation (2) was used to calculate RMS wind errors based on winds computed over 50-meter intervals for each radar track. Eighty-one data points were used to calculate the RMS errors over each two-kilometer layer. The individual test results are given in Appendix A for Cape Kennedy, Florida and Appendix B for Green River, Utah. Appendix C lists the test number, date, time (Z), and radar for the simultaneous dual tracks of a single balloon sensor.

The RMS errors as a function of altitude and slant range are summarized for each location Cape Kennedy, Green River, and Pt. Mugu.

III. TEST RESULTS

A. Cape Kennedy, Florida

Appendix A contains the RMS errors for zonal (V_x), meridional (V_y), scalar (V), and vertical (V_z) wind speeds as a function of azimuth angle (Φ), elevation angle (θ), and slant range (r). The RMS error data were calculated for two-kilometer layers up to about 18 km altitude.

The table below gives the mean values of the RMS errors obtained from the seventeen Cape Kennedy tests. The distance between Cape Kennedy's FPS-16 radar (1.16) with Merritt Island's TPQ-18 (19.18), and Patrick AFB's TPQ-6 (0.18) is 11,535 and 28,499 meters, respectively.

Altitude Intervals	Mean of RMS Errors (17 Cases)			
(m)	V_x m sec^{-1}	V_y m sec^{-1}	V m sec^{-1}	V_z m sec^{-1}
2000 - 3975	0.17	0.13	0.17	0.15
4000 - 5975	0.16	0.13	0.16	0.14
6000 - 7975	0.19	0.14	0.19	0.20
8000 - 9975	0.27	0.15	0.29	0.26
10,000 - 11,975	0.29	0.29	0.30	0.36
12,000 - 13,975	0.37	0.48	0.40	0.52
14,000 - 15,975	0.53	0.71	0.52	0.75
16,000 - 17,975	0.49	0.51	0.49	0.57
OVERALL AVERAGE	0.31	0.32	0.32	0.37

Figure 2 contains a plot of the slant range versus elevation angle data from 17 dual Jimsphere tracks at Cape Kennedy. The numbers above the X's are the RMS errors of wind speed. The figure shows that up to a slant range of 30 km, while the elevation angles were between approximately 83 and 13 degrees, depending on the wind speed, the wind speed RMS errors are well below 0.5 m sec^{-1}. From 30 to 70 km slant range, the elevation angle ranged from 25 to 9 degrees and the RMS errors were usually under 0.5 m sec^{-1}. During these operational tests, however, a few occasional points were above 0.5 m sec^{-1}. From 70 to 100 km slant range, the elevation angle was between 12 and 8 degrees. At these low elevation angles and high slant ranges, the wind speed RMS error varied from 0.35 m sec^{-1} to 0.67 m sec^{-1}, except for one case when the RMS error was 1.1 m sec^{-1}. This isolated case occurred at a slant range of about 70 km and 13 degrees elevation angle, and appears, from the data records, to have been caused by an erratic radar tracking performance or error in transcribing the tracking data records.

From 100 to 132 km slant range, the elevation angles were between 8.0 and 5.9 degrees. At these very low elevation angles and large slant ranges (minimum elevation angle of 5.9 degrees and maximum slant range of 132 km), the wind speed RMS error value varied from 0.48 m sec^{-1} to 0.72 m sec^{-1}. During these periods of the tests, the wind speeds varied from 20 to 67 m sec^{-1}.

B. Green River, Utah

The table below gives the mean values of the RMS errors obtained from the 12 tests at Green River, Utah. The distance between the FPS-16 radars 218 and 219 is 153 m, while the distance between radars 218 and 255 is 53 m.

Altitude Intervals	Mean of RMS Errors (12 Cases)			
(m)	V_x m sec^{-1}	V_y m sec^{-1}	V m sec^{-1}	V_z m sec^{-1}
2000 - 3975	0.11	0.14	0.16	0.11
4000 - 5975	0.12	0.07	0.11	0.06
6000 - 7975	0.18	0.11	0.19	0.08
8000 - 9975	0.22	0.12	0.27	0.10
10,000 - 11,975	0.21	0.15	0.21	0.17
12,000 - 13,975	0.20	0.22	0.26	0.25
14,000 - 15,975	0.19	0.26	0.19	0.36
16,000 - 17,975	0.18	0.27	0.28	0.40
OVERALL AVERAGE	0.18	0.17	0.21	0.19

Figure 3 contains a plot of the 12 dual tracks at Green River, Utah with elevation angles shown versus slant ranges. The RMS error values for the wind speed are printed above the X's. The figure shows that, for slant ranges up to 30 km, the elevation angles range from about 45 degrees to 12 degrees. The RMS values were well withon 0.5 m sec^{-1}. From 30 to 70 km slant range, the elevation angle ranged from 15 to 9 degrees. Within this region, the RMS errors were below 0.58 m sec^{-1}. From 70 to 90 km slant range, the elevation angles were between 12 and 9 degrees and the maximum RMS error was 0.32 m sec^{-1}.

An important test series in this accuracy study was obtained at Green River, Utah, where seven Jimspheres were released approximately one hour apart on December 12, 1967. Each of these releases was tracked by two radars. Figure 4 shows the wind speed plotted versus altitude for these seven FPS-16 radar/Jimsphere wind profiles. The first profile indicated a maximum wind speed of 68 m sec^{-1} at approximately 10,500 m altitude. In the succeeding profiles, the maximum wind speed may be easily followed. In the approximate seven-hour elapsed time, the maximum wind speed diminished to about 45 m sec^{-1}. The detailed wind profile features show a remarkable persistence from one profile to the next; this has previously been discussed [6]. The maximum RMS error for this special test series of seven profiles was 0.58 m sec^{-1}.

C. Pt. Mugu

The results of one dual radar track of a Jimsphere made on March 20, 1968, are similar to the results obtained at Cape Kennedy, Florida and Green River, Utah. The table below and particularly figure 5 shows that the elevation angle ranged from about 27 to 15 degrees up to 30 km slant range. The wind speed RMS errors were well below 0.5 m sec^{-1}. From 30 to 70 km slant range, the elevation angle was between 15 and 10 degrees. The wind speed RMS error ranged from 0.25 to 0.65 m sec^{-1}. From 70 to 96.6 km slant range, the elevation angle was between 10.0 and 9.7 degrees for wind speed RMS errors of approximately 0.5 m sec^{-1}. During this track, the wind speed was approximately 65 m sec^{-1} at about 12.4 km altitude.

Table of RMS Errors in Wind Data as Function of Altitude

Test No.: 81517-01 Date: March 20, 1968

Location: Pt. Mugu* Time: 0127GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x m sec^{-1}	V_y m sec^{-1}	V m sec^{-1}	V_z m sec^{-1}	Φ deg.	θ deg.	r (m)
2000-3975	0.06	0.15	0.11	0.08	185.63	26.86	6,629
4000-5975	0.15	0.21	0.26	0.09	213.76	19.59	14,862
6000-7975	0.15	0.23	0.26	0.10	212.34	15.38	26,202
8000-9975	0.14	0.31	0.25	0.13	199.14	13.77	37,367
10000-11975	0.13	0.53	0.42	0.17	181.66	12.14	51,367
12000-13975	0.37	0.63	0.65	0.40	167.96	10.01	72,559
14000-15975	0.46	0.55	0.51	0.47	160.72	9.51	86,675
16000-17975	0.46	0.29	0.40	0.59	157.93	9.69	96,619
OVERALL AVERAGE	0.24	0.36	0.35	0.25			

*Radar height above MSL 12.8 m, distance between the FPS 16-radars is 207 meters.

IV. SUMMARY REMARKS

RMS errors were obtained by tracking a Jimsphere simultaneously with two FPS-16 radars (or equivalent for Cape Kennedy tests). Thirty dual tracks from Cape Kennedy, Pt. Mugu, and Green River were conducted to obtain a better understanding for the operational accuracy of the FPS-16 radar/Jimsphere system. Contributing to the RMS error of the Jimsphere are the condition of the radar, operator's experience, data editing, and the angular position of the balloon. The RMS error is approximately 0.5 m sec^{-1} or less for the component wind speeds, zonal (V_x) and meridional (V_y), the scalar wind speed (V) and vertical velocity of the balloon (V_z) for elevation angles above 10 degrees and a slant range of 100 km. This is in agreement with an earlier [2] conclusion for the RMS errors of 0.5 m sec^{-1} for slant ranges of 80 km and above 12.9 degrees elevation angle.

Several tests at Cape Kennedy were obtained when the slant ranges were beyond 100 km. From 100 to 132 km at low elevation angles (8.0 to 5.9 degrees), the RMS error wind speed error values ranged from 0.48 to 0.72 m sec^{-1}. These large values may be attributed to radar performance at low elevation angles and greater slant ranges. Special attention to the careful selection of the radar settings (servo-bandwidth, etc.) and calibrations will improve the tracking data characteristics. This improvement may be desirable for certain research activities. The variation of wind speed error with elevation angle is further illustrated in reference 5.

The means of the RMS errors computed from values at two-kilometer layers up to 18 km altitude for V_x, V_y, V_z and V were obtained from seventeen cases at Cape Kennedy. The range of RMS errors was 0.31 to 0.37 m sec^{-1}. Similarly, the means of the RMS errors computed from twelve cases at Green River varied from 0.17 to 0.21 m sec^{-1}. The range of RMS errors was less at Green River than at Cape Kennedy and the one case at Pt. Mugu had an RMS error range of 0.24 to 0.3[illegible] m sec^{-1}.

The thirty dual tracks from the three ranges indicate that the wind measurement system under practical operational consideration is very dependable and accurate. The total ascent time for the Jimsphere to reach 14.6 km altitude is about 50 minutes and 17.5 km altitude about 60 minutes (Figure 6). The use of these detailed wind profiles in aerospace vehicle and meteorological studies has improved considerably the understanding of vehicle response characteristics [7] and meso-meteorological phenomena [8] not previously possible.

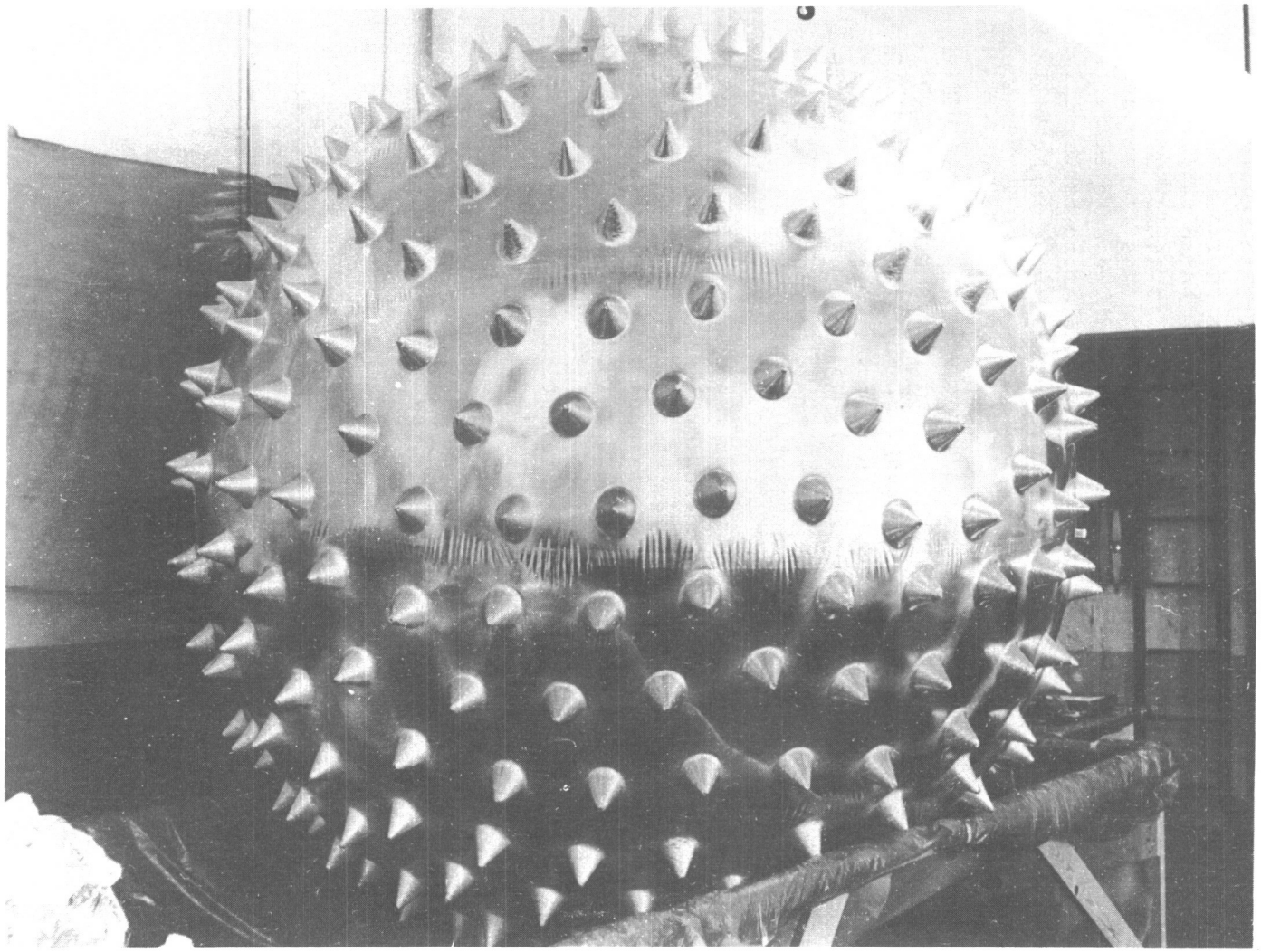

Figure 1. Operational Configuration of Jimsphere, ML 632/UM (6660-115-3686). Dia. of Jimsphere 2-M; Diameter and Height of Full Cones, 0.076-M (3in.) Total Number of Cones, 398.

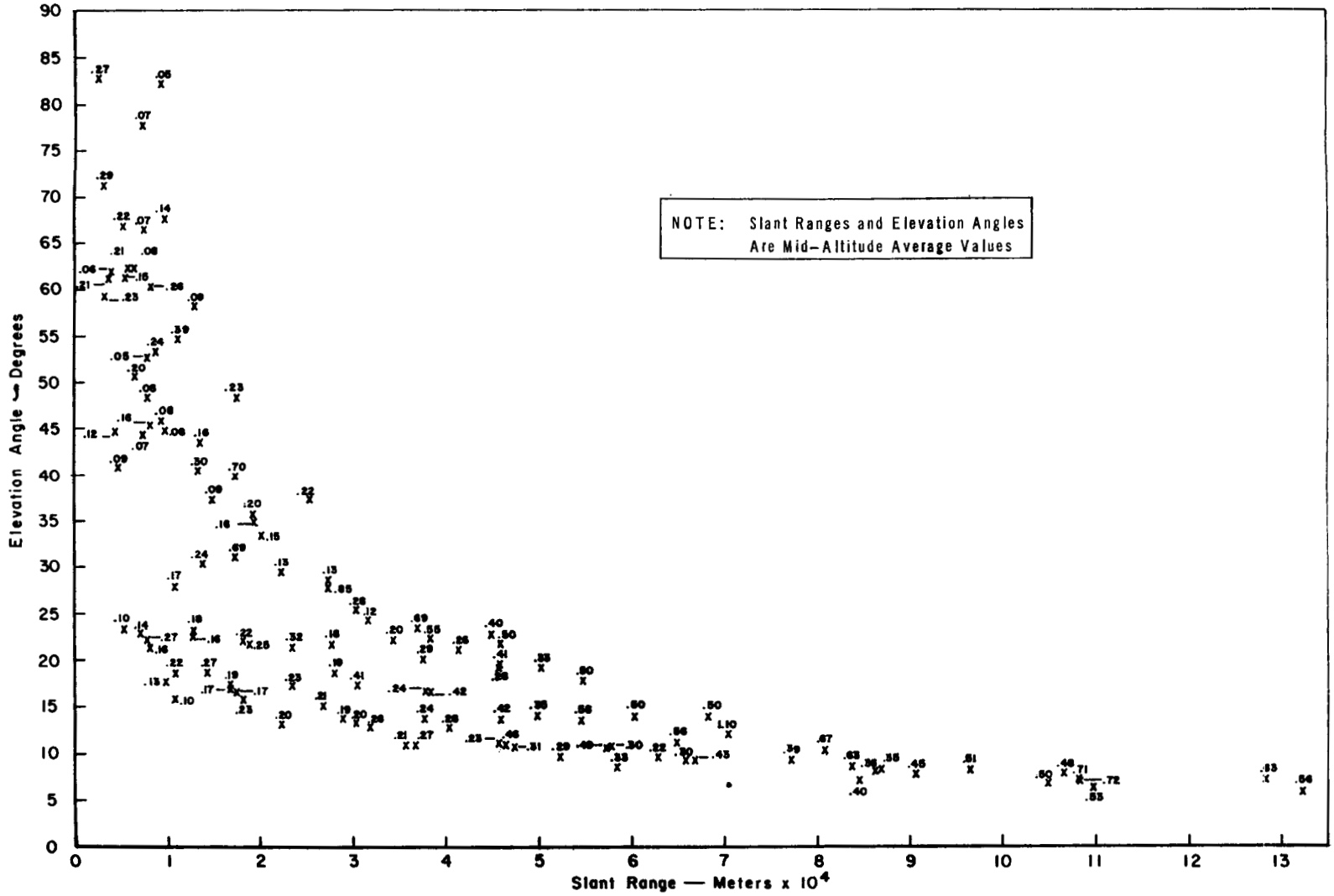

FIGURE 2. RMS ERRORS OF WIND SPEED (V) AS A FUNCTION OF SLANT RANGE (R) VERSUS ELEVATION ANGLE (θ) FOR DUAL FPS-16 RADAR/JIMSPHERE TRACKING AT CAPE KENNEDY, FLORIDA

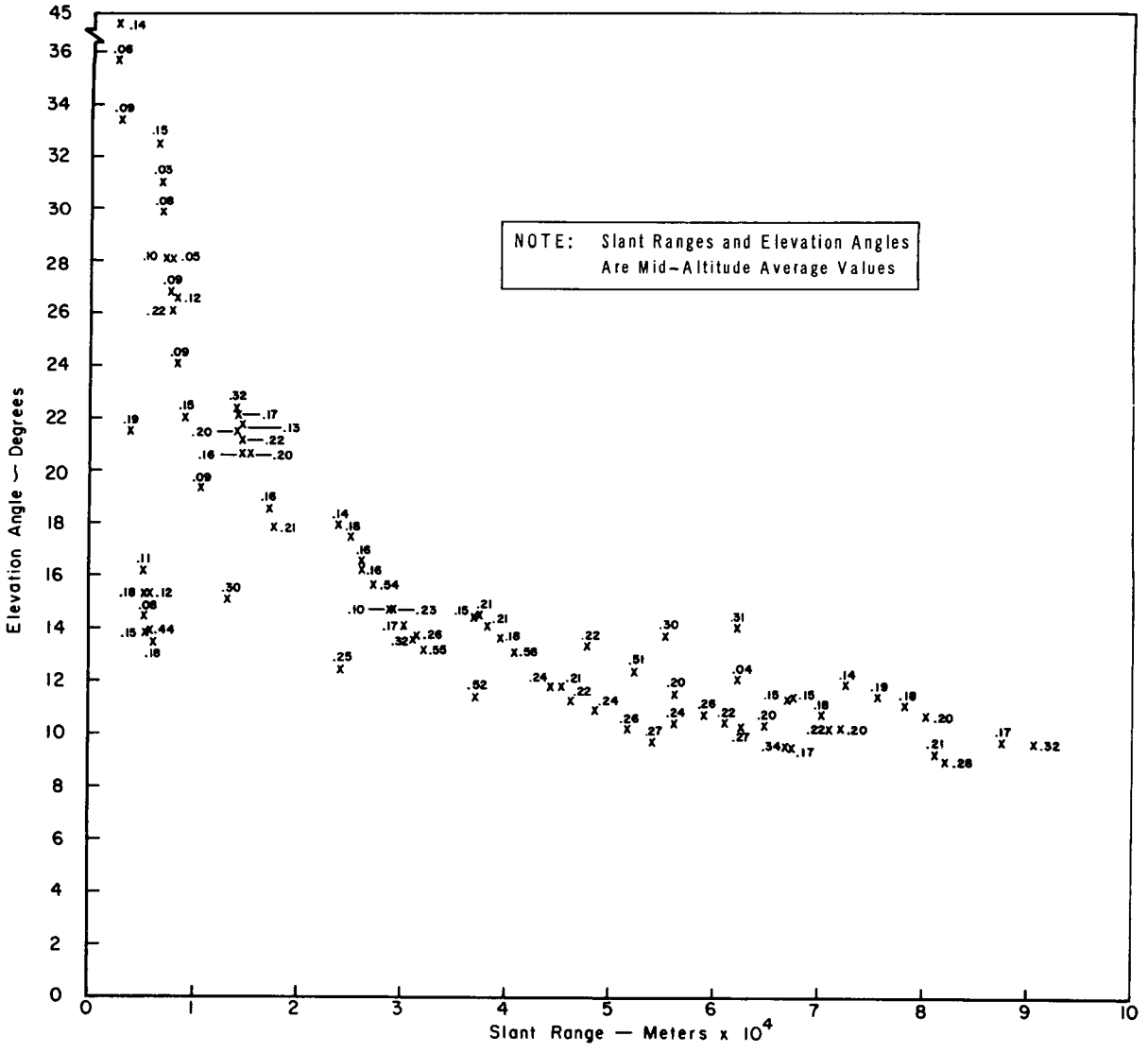

FIGURE 3. RMS ERRORS OF WIND SPEED (V) AS A FUNCTION OF SLANT RANGE (R) VERSUS ELEVATION ANGLE (θ) FOR DUAL FPS-16 RADAR/JIMSPHERE TRACKING AT GREEN RIVER, UTAH

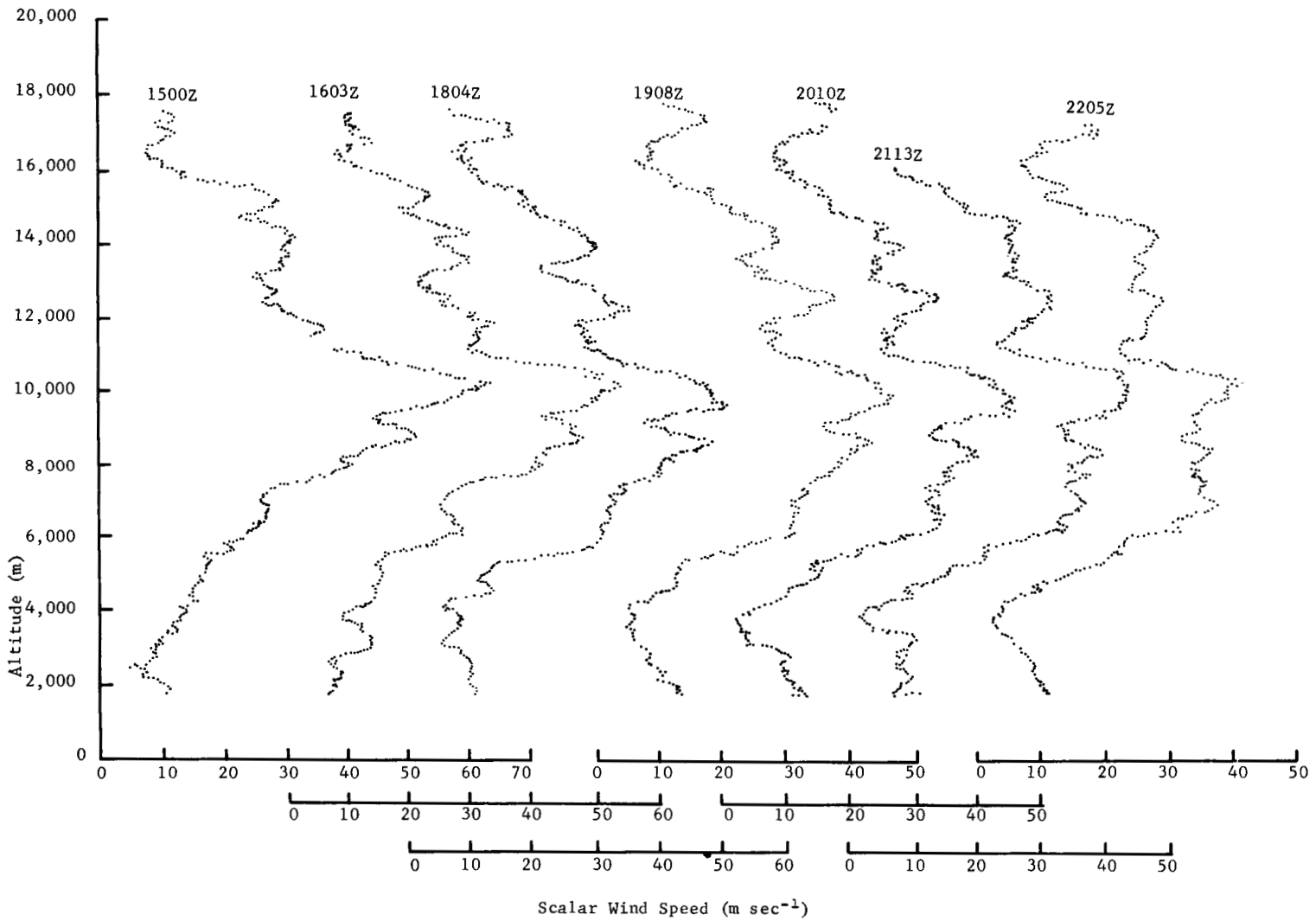

Figure 4. Composite of Seven FPS-16 Radar/Jimsphere Wind Profile Measurements
Green River, Utah, December 12, 1967
Scalar Wind Speed vs Altitude

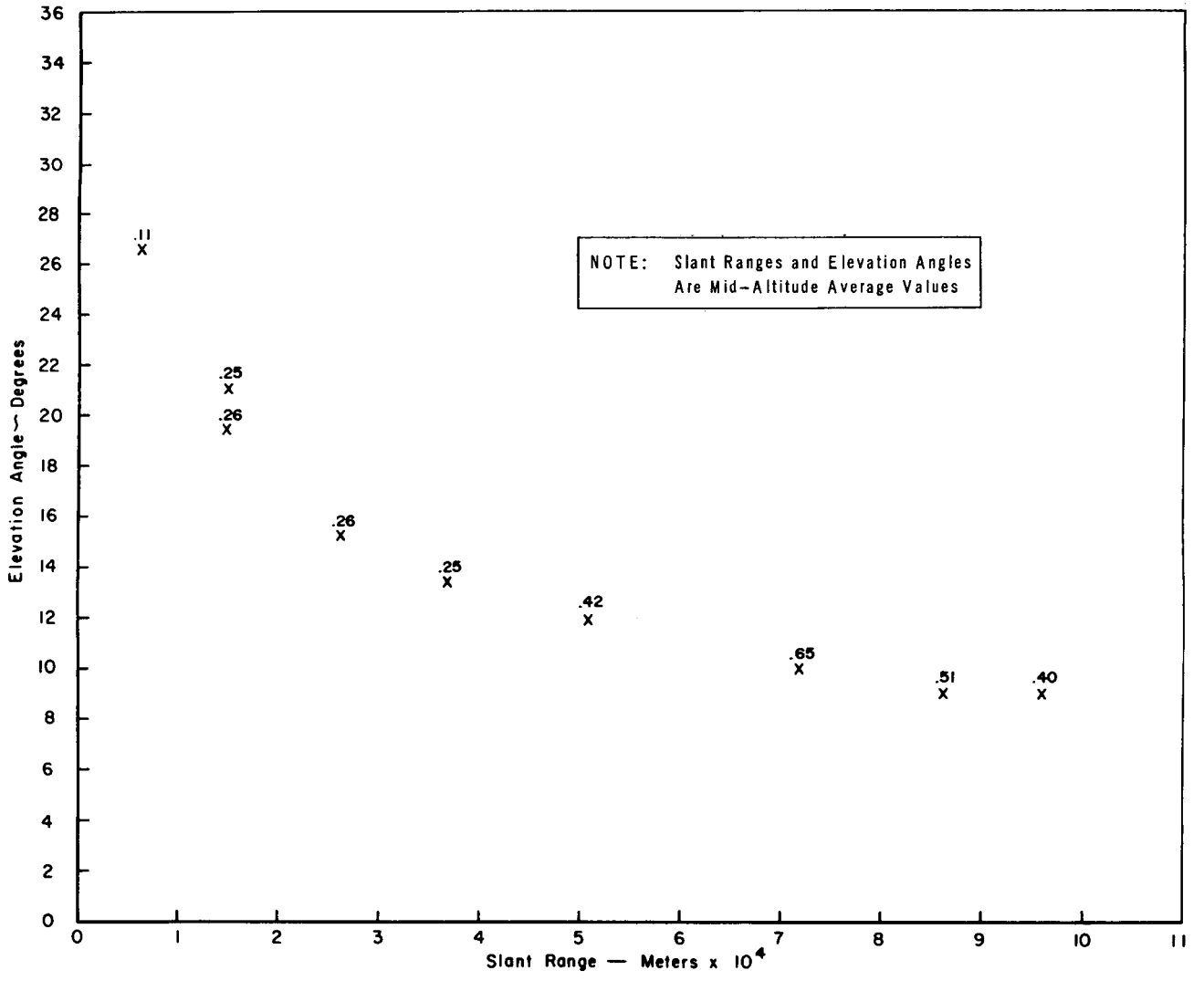

FIGURE 5. RMS ERRORS OF WIND SPEED (V) AS A FUNCTION OF SLANT RANGE (R) VERSUS ELEVATION ANGLE (θ) FOR DUAL FPS-16 RADAR/JIMSPHERE TRACKING AT PT. MUGU, CALIFORNIA

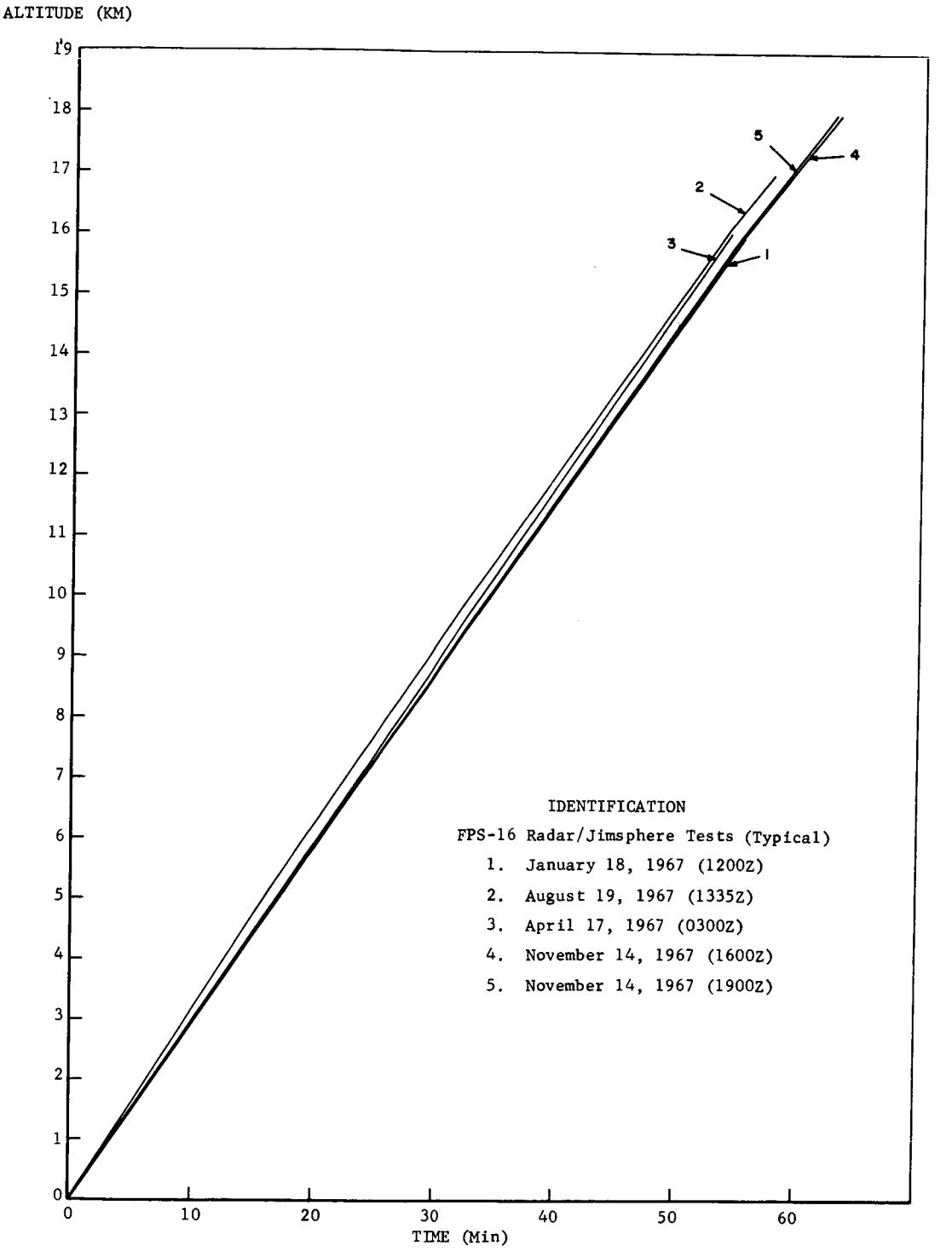

Figure 6. Time vs Altitude Comparison of Jimsphere Wind Sensor

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APPENDIX A. TABLES A-1 THROUGH A-17

WIND PROFILE RMS ERROR DATA FOR SIMULTANEOUS DUAL RADAR TRACK OF SINGLE JIMSPHERE

CAPE KENNEDY, FLORIDA

Symbol

V_x	zonal wind speed, positive east	m sec^{-1}
V_y	meridional wind speed, positive north	m sec^{-1}
V	scalar wind speed	m sec^{-1}
V_z	vertical balloon speed, positive upward	m sec^{-1}
Φ	azimuth angle	deg
θ	elevation angle	deg
r	slant range	m

Radar Heights above MSL

FPS-16	(1.16)	17.1 m
TPQ-6	(0.18)	18.5 m
TPQ-18	(19.18)	11.3 m.

Table A-1. Mid-Altitude Average Value of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude.

Test No.: 1790-2 Date: December 18, 1967

Location: Cape Kennedy, Florida Time: 1300 GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3915	0.10	0.10	0.09	0.06	54.85	40.80	4,585
4000-5975	0.09	0.11	0.08	0.08	69.03	48.31	6,688
6000-7975	0.09	0.11	0.08	0.06	67.04	45.76	9,764
8000-9975	0.35	0.17	0.30	0.12	66.71	40.48	13,844
10000-11975	0.14	0.12	0.13	0.08	63.14	33.13	20,081
12000-13975	0.15	0.09	0.13	0.08	62.71	28.16	27,444

Table A-2. Mid-Altitude Average Value of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 1790-5 Date: December 21, 1967

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
*2000-3975	-	-	-	-	-	-	-
4000-5975	0.12	0.08	0.08	0.06	318.41	62.75	5,623
6000-7975	0.07	0.07	0.07	0.07	339.29	77.18	7,178
8000-9975	0.14	0.06	0.05	0.15	172.15	82.25	9,086
10000-11975	0.13	0.09	0.09	0.13	171.89	57.98	12,969
12000-13975	0.20	0.19	0.23	0.09	160.40	48.03	17,469
14000-15975	0.21	0.19	0.22	0.13	142.53	37.21	24,750

*No data available.

Table A-3. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 8426-04 Date: January 30, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.27	0.20	0.27	0.13	72.60	82.72	3,023
4000-5975	0.17	0.14	0.15	0.09	174.53	67.14	5,427
6000-7975	0.17	0.16	0.16	0.09	165.07	45.14	9,817
8000-9975	0.28	0.65	0.69	0.18	163.83	31.11	17,386
10000-11975	0.13	0.17	0.18	0.11	160.77	23.42	27,562
12000-13975	0.28	0.28	0.29	0.16	157.38	20.00	37,697
14000-15975	0.44	0.24	0.41	0.25	152.68	18.93	45,789

Table A-4. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 8426-08 Date: February 1, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.22	0.16	0.21	0.14	187.97	61.64	3,409
4000-5975	0.19	0.18	0.21	0.17	146.82	61.78	5,672
6000-7975	0.25	0.30	0.24	0.15	123.01	53.51	8,703
8000-9975	0.16	0.12	0.16	0.11	116.49	43.24	13,127
10000-11975	0.16	0.13	0.16	0.13	115.34	34.59	19,338
12000-13975	0.27	0.19	0.28	0.22	113.57	25.24	30,348
14000-15975	0.25	0.25	0.26	0.38	108.68	21.22	41,124
16000-17975	0.33	0.43	0.33	0.45	106.90	19.65	50,012

Table A-5. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2780-3 Date: February 5, 1968

Location: Cape Kennedy, Florida Time: 1308GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.27	0.27	0.29	0.35	75.15	71.55	3,160
4000-5975	0.19	0.19	0.20	0.18	80.95	50.64	6,465
6000-7975	0.26	0.16	0.24	0.17	74.07	30.16	13,920
8000-9975	0.34	0.22	0.32	0.24	74.16	21.47	24,470
10000-11975	0.46	0.41	0.42	0.41	75.66	16.49	38.387
12000-13975	0.59	0.70	0.49	0.58	73.06	13.53	54,538
14000-15975	0.87	1.06	0.69	1.10	73.34	12.01	70,317

Table A-6. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2780-09 Date: February 9, 1968

Location: Cape Kennedy, Florida Time: 1331GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.16	0.14	0.16	0.12	118.34	21.12	8,295
4000-5975	0.18	0.11	0.19	0.11	121.74	17.41	16,635
6000-7975	0.18	0.11	0.20	0.24	116.54	13.35	30,018
8000-9975	0.46	0.23	0.46	0.40	110.20	10.96	46,478
10000-11975	0.22	0.33	0.22	0.57	105.95	9.50	64,659
12000-13975	0.33	0.84	0.36	0.89	102.49	8.29	86,187
14000-15975	0.49	1.15	0.48	1.17	99.15	7.62	106,515

Table A-7. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 6656-01 Date: February 14, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.13	0.08	0.14	0.07	124.20	22.81	7,230
4000-5975	0.16	0.09	0.17	0.12	117.57	17.44	16,621
6000-7975	0.18	0.13	0.19	0.15	114.30	13.86	28,943
8000-9975	0.22	0.21	0.23	0.24	111.65	11.19	45,539
10000-11975	0.28	0.35	0.30	0.59	115.08	9.34	65,720
12000-13975	0.35	0.46	0.35	0.85	111.39	8.24	86,689
14000-15975	0.52	0.99	0.50	1.13	107.44	7.69	105,259

Table A-8. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 6456-08 Date: February 16, 1968

Location: Cape Kennedy, Florida Time: 1305 GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.26	0.17	0.27	0.22	95.08	18.91	9,238
4000-5975	0.17	0.14	0.17	0.13	91.63	16.79	17,247
6000-7975	0.21	0.13	0.21	0.16	89.49	15.13	26,617
8000-9975	0.28	0.20	0.28	0.29	87.14	12.77	40,166
10000-11975	0.33	0.45	0.30	0.41	84.17	10.75	57,629
12000-13975	0.40	0.70	0.39	0.75	82.49	9.35	77,263
14000-15975	0.54	1.18	0.51	0.99	82.54	8.48	96,644

Table A-9. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 1460-1 Date: February 26, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.12	0.08	0.13	0.10	121.15	17.65	9,864
4000-5975	0.21	0.11	0.22	0.23	95.36	18.72	10,672
6000-7975	0.27	0.17	0.27	0.19	106.49	10.78	36,881
8000-9975	0.33	0.36	0.33	0.61	102.26	8.55	58,759
10000-11975	0.39	0.73	0.40	1.12	99.29	7.08	84,811
12000-13975	0.39	1.13	0.53	1.27	97.32	6.32	109,737
14000-15975	0.55	1.24	0.56	1.24	95.78	5.91	132,284

Table A-10. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 1460-2 Date: February 28, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.10	0.04	0.10	0.10	99.59	23.18	5,478
4000-5975	0.18	0.09	0.18	0.23	99.24	23.00	12,758
6000-7975	0.24	0.13	0.23	0.78	101.53	17.38	23,308
8000-9975	0.25	0.18	0.24	0.59	102.52	13.68	37,588
10000-11975	0.50	0.46	0.49	0.89	102.45	10.78	57,454
12000-13975	0.64	0.68	0.63	1.06	102.26	8.54	83,849
14000-15975	0.74	1.02	0.71	1.49	100.45	7.46	108,505
16000-17975	0.65	1.12	0.63	0.98	99.23	7.03	128,419

Table A-11. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2105-03 Date: March 5, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.26	0.19	0.27	0.14	110.86	22.27	7,902
4000-5975	0.22	0.18	0.23	0.13	110.72	15.92	18,135
6000-7975	0.28	0.16	0.28	0.19	108.68	12.64	31,642
8000-9975	0.29	0.22	0.31	0.33	106.36	10.77	47,245
10000-11975	0.38	0.40	0.43	0.52	106.33	9.15	66,978
12000-13975	0.40	0.72	0.45	0.84	107.42	7.84	90,679
14000-15975	0.64	1.20	0.72	0.86	105.65	7.47	108,394

Table A-12. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 1454-5 Date: March 6, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.20	0.08	0.18	0.16	96.19	18.40	9,479
4000-5975	0.20	0.15	0.20	0.42	86.20	13.03	22,016
6000-7975	0.21	0.19	0.21	0.48	86.09	10.89	35,714
8000-9975	0.28	0.23	0.29	0.67	85.09	9.69	52,206

Table A-13. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2688-7 Date: March 11, 1968

Location: Cape Kennedy, Florida Time: 1302GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
*2000-3975	-	-	-	-	-	-	-
4000-5975	0.16	0.11	0.17	0.08	76.03	27.81	10,703
6000-7975	0.25	0.13	0.25	0.13	79.03	21.92	18,685
8000-9975	0.40	0.23	0.41	0.21	81.95	17.26	30,121
10000-11975	0.41	0.28	0.42	0.28	85.95	13.71	45,779
12000-13975	0.57	0.63	0.56	0.76	88.37	11.29	64,712
14000-15975	0.68	0.91	0.67	1.06	87.28	10.36	80,723

*No data available.

Table A-14. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2688-8 Date: March 15, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.12	0.06	0.12	0.11	282.01	44.93	4,245
4000-7975	0.07	0.07	0.07	0.07	289.07	44.51	7,129
6000-7975	0.10	0.08	0.07	0.07	288.54	67.11	7,597
8000-9975	0.14	0.11	0.14	0.11	95.76	68.11	9,699
10000-11975	0.19	0.17	0.20	0.13	103.10	35.13	19,082
12000-13975	0.19	0.24	0.20	0.24	103.39	22.11	34,327
14000-15975	0.29	0.28	0.28	0.46	105.83	18.84	45,958
16000-17975	0.45	0.49	0.50	0.70	104.64	17.81	54,864

Table A-15. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2026-1 Date: March 19, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.08	0.09	0.10	0.08	67.96	15.79	10,997
4000-5975	0.09	0.14	0.16	0.07	91.98	22.99	12,760
6000-7975	0.13	0.19	0.22	0.08	112.29	22.06	18,103
8000-9975	0.14	0.15	0.19	0.10	121.35	18.87	27,670
10000-11975	0.21	0.18	0.24	0.16	124.62	16.80	37,704
12000-13975	0.34	0.30	0.35	0.26	124.52	14.92	49,814
14000-15975	0.47	0.46	0.50	0.44	122.99	14.19	60,107
16000-17975	0.51	0.46	0.50	0.65	121.57	14.17	68,018

Table A-16. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2272-1 Date: March 20, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.07	0.06	0.06	0.11	146.17	62.28	3,387
4000-5975	0.07	0.06	0.05	0.07	155.11	52.58	6,294
6000-7975	0.07	0.07	0.08	0.10	138.74	44.74	9,834
8000-9975	0.09	0.10	0.09	0.10	119.18	37.43	14,788
10000-11975	0.13	0.10	0.13	0.10	108.04	29.53	22,242
12000-13975	0.13	0.14	0.12	0.15	102.83	24.23	31,510
14000-15975	0.55	0.22	0.55	0.26	102.27	22.52	38,907
16000-17975	0.60	0.24	0.60	0.29	103.14	21.67	45,645

Table A-17. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 2990-1 Date: March 21, 1968

Location: Cape Kennedy, Florida Time: 1300GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.18	0.23	0.23	0.29	52.82	59.06	3,437
4000-5975	0.21	0.20	0.22	0.22	34.80	66.87	5,383
6000-7975	0.25	0.16	0.26	0.23	45.42	60.32	8,017
8000-9975	0.37	0.18	0.39	0.18	74.51	54.66	11,093
10000-11975	0.67	0.25	0.70	0.19	88.08	39.62	17,289
12000-13975	0.77	0.40	0.85	0.19	100.47	27.83	27,683
14000-15975	0.69	0.20	0.69	0.26	97.58	23.51	37,386
16000-17975	0.39	0.32	0.40	0.32	96.43	22.29	44,636

APPENDIX B. TABLES B-1 THROUGH B-12

WIND PROFILE RMS ERROR DATA FOR SIMULTANEOUS DUAL RADAR TRACK OF SINGLE JIMSPHERE

GREEN RIVER, UTAH

Symbols

V_x	zonal wind speed, positive east	m sec^{-1}
V_y	meridional wind speed, positive north	m sec^{-1}
V	scalar wind speed	m sec^{-1}
V_z	vertical balloon speed, positive upward	m sec^{-1}
Φ	azimuth angle	deg
θ	elevation angle	deg
r	slant range	m

Radar Height above MSL

1,568 m.

Table B-1. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10163-01 Date: December 11, 1967

Location: Green River, Utah Time: 1601GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.16	0.12	0.19	0.15	141.77	21.44	3,910
4000-5975	0.25	0.18	0.30	0.07	129.74	15.14	13,084
6000-7975	0.19	0.17	0.25	0.07	130.10	12.52	24,828
8000-9975	0.39	0.36	0.52	0.13	132.17	11.40	37,066
10000-11976	0.22	0.20	0.26	0.26	131.52	10.26	51.786
12000-13975	0.28	0.30	0.34	0.40	130.45	9.48	67,222
14000-15975	0.35	0.41	0.28	0.80	130.16	9.04	82,192
16000-17975	0.39	0.42	0.32	0.63	129.82	9.41	90,417

Table B-2. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10164-01 Date: December 12, 1967

Location: Green River, Utah Time: 1500GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.07	0.11	0.12	0.04	145.07	15.35	5,398
4000-5975	0.10	0.05	0.09	0.04	124.26	19.96	10,031
6000-7975	0.23	0.08	0.21	0.08	101.95	17.91	17,587
8000-9975	0.36	0.06	0.35	0.11	91.68	13.24	32,116
10000-11975	0.27	0.12	0.27	0.21	90.05	9.73	54,708
12000-13975	0.18	0.19	0.17	0.30	89.90	9.45	67,424
14000-15975	0.21	0.29	0.21	0.39	90.17	9.30	80,125
16000-17975	0.15	0.27	0.17	0.34	91.26	9.76	87,629

Table B-3. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10165-01 Date: December 12, 1967

Location: Green River, Utah Time: 1603GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.09	0.12	0.18	0.04	145.60	15.21	5,416
4000-5975	0.16	0.08	0.15	0.08	125.31	22.09	9,108
6000-7975	0.18	0.04	0.16	0.06	97.10	18.55	17,008
8000-9975	0.27	0.07	0.26	0.08	88.69	13.65	31,094
10000-11975	0.27	0.15	0.27	0.20	87.43	10.28	62,527
12000-13975	0.20	0.38	0.20	0.28	87.13	10.33	64,754
14000-15975	0.19	0.31	0.20	0.38	88.03	10.26	72,269
16000-17975	0.15	0.28	0.20	0.52	89.76	10.72	80,368

Table B-4. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10167-01 Date: December 12, 1967

Location: Green River, Utah Time: 1804GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.09	0.16	0.18	0.12	148.62	13.46	6,137
4000-5975	0.10	0.07	0.09	0.05	131.56	24.18	8,365
6000-7975	0.22	0.43	0.20	0.08	92.44	20.68	15,363
8000-9975	0.32	0.07	0.32	0.11	84.56	13.61	31,268
10000-11975	0.25	0.13	0.24	0.12	82.90	10.97	48,639
12000-13975	0.22	0.16	0.22	0.24	82.45	10.46	61,339
14000-15975	0.21	0.24	0.22	0.35	84.13	10.50	71,175
16000-17975	0.15	0.23	0.18	0.24	84.47	11.10	77,782

Table B-5. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10168 Date: December 12, 1967

Location: Green River, Utah Time: 1908GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.21	0.39	0.44	0.33	147.11	13.81	5,990
4000-5975	0.20	0.12	0.22	0.10	133.30	26.07	7,795
6000-7975	0.19	0.03	0.17	0.08	88.14	21.83	14,564
8000-9975	0.25	0.07	0.24	0.11	80.05	14.04	30,341
10000-11975	0.23	0.13	0.22	0.16	78.52	11.36	47,027
12000-13975	0.25	0.20	0.26	0.22	79.43	10.76	59,803
14000-15975	0.19	0.22	0.18	0.37	81.35	10.67	70,514
16000-17975	0.15	0.22	0.19	0.29	80.73	11.44	75,663

Table B-6. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No: 10169 Date: December 12, 1967

Location: Green River, Utah Time: 2010GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.06	0.14	0.15	0.09	149.42	13.79	5,992
4000-5975	0.08	0.04	0.05	0.05	132.41	28.17	7,261
6000-7975	0.18	0.04	0.17	0.07	83.08	22.14	14,373
8000-9875	0.22	0.07	0.10	0.10	77.03	14.80	28,852
10000-11975	0.21	0.11	0.21	0.12	76.01	11.81	45,323
12000-13975	0.20	0.16	0.20	0.26	76.97	11.44	56,214
14000-15975	0.16	0.18	0.15	0.27	78.06	11.42	67,199
16000-17975	0.12	0.22	0.14	0.28	78.72	11.98	72,505

Table B-7. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10170 Date: December 12, 1967

Location: Green River, Utah Time: 2113GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.05	0.10	0.11	0.09	148.79	16.25	5,110
4000-5975	0.07	0.04	0.05	0.05	132.26	32.52	6,377
6000-7975	0.20	0.07	0.20	0.09	79.18	21.51	14,769
8000-9975	0.22	0.09	0.23	0.08	73.68	14.82	28,831
10000-11975	0.24	0.11	0.24	0.14	74.55	11.98	44,697
12000-13975	0.20	0.17	0.20	0.20	76.37	11.43	56,470
14000-15975	0.15	0.18	0.15	0.21	76.49	11.32	66,740

Table B-8. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10171 Date: December 12, 1967

Location: Green River, Utah Time: 2205GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.04	0.07	0.08	0.03	151.32	14.30	5,800
4000-5975	0.06	0.06	0.03	0.05	137.69	31.12	6,635
6000-7975	0.30	0.12	0.32	0.09	81.86	22.29	14,283
8000-9975	0.49	0.22	0.54	0.10	74.12	15.63	27,385
10000-11975	0.06	0.15	0.58	0.15	75.06	13.13	40,966
12000-13975	0.05	0.19	0.51	0.16	75.67	12.45	52,105
14000-15975	0.04	0.16	0.04	0.20	75.61	12.15	62,449

Table B-9. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10214-02 Date: February 13, 1968

Location: Green River, Utah Time: 1630GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.11	0.09	0.09	0.07	103.18	33.34	2,600
4000-5975	0.10	0.05	0.10	0.05	64.78	28.08	7,285
6000-7975	0.11	0.06	0.13	0.06	62.45	21.67	14,677
8000-9975	0.16	0.11	0.18	0.08	58.52	17.49	24,584
10000-11975	0.18	0.21	0.21	0.21	57.11	14.46	37,362

Table B-10. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10216-1 Date: February 13, 1968

Location: Green River, Utah Time: 1830 GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
*2000-3975	-	-	-	-	-	-	-
4000-5975	0.08	0.03	0.08	0.08	58.41	29.82	6,891
6000-7975	0.12	0.06	0.09	0.05	54.65	23.45	16,518
8000-9975	0.13	0.08	0.14	0.06	52.13	17.96	23,980
10000-11975	0.18	0.10	0.15	0.08	52.27	14.55	37,165

*No data available.

Table B-11. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10217-02 Date: February 13, 1968

Location: Green River, Utah Time: 1930GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.08	0.05	0.06	0.05	91.80	35.73	2,455
4000-5975	0.08	0.06	0.09	0.05	54.74	26.75	7,616
6000-7975	0.11	0.16	0.16	0.10	54.65	20.72	15,296
8000-9975	0.13	0.11	0.16	0.10	52.81	16.47	26,013
10000-11975	0.22	0.21	0.21	0.17	52.20	14.03	38,418
12000-13975	0.26	0.22	0.22	0.23	52.76	13.63	47,694
14000-15975	0.29	0.37	0.30	0.28	53.97	13.76	55,419
16000-17975	0.33	0.24	0.31	0.48	55.09	14.02	62,328

Table B-12. Mid-Altitude Average Values of Radar Coordinates and RMS Errors in Wind Data as Function of Altitude

Test No.: 10218-01 Date: February 13, 1968

Location: Green River, Utah Time: 2035GMT

Altitude Intervals (m)	RMS Errors				Mid-Altitude Average Values		
	V_x (m sec^{-1})	V_y (m sec^{-1})	V (m sec^{-1})	V_z (m sec^{-1})	$\bar{\Phi}$ (deg)	$\bar{\theta}$ (deg)	$\bar{r}$ (m)
2000-3975	0.22	0.15	0.14	0.18	104.77	43.79	2,076
4000-5975	0.10	0.07	0.12	0.06	53.15	26.65	7,641
*6000-7975	-	-	-	-	-	-	-
8000-9975	0.14	0.11	0.16	0.09	53.43	16.21	26,445
10000-11975	0.16	0.18	0.18	0.17	52.08	13.63	39,519

*No data available.

APPENDIX C

SIMULTANEOUS DUAL TRACK SINGLE JIMSPHERE WIND PROFILE DATA

CAPE KENNEDY, FLORIDA

Table	Test No.	Date	Time (GMT)	Radar
A-1	1790-02	December 18, 1967	1300	19.18*
	1790-02	" " "	1300	1.16
A-2	1790-05	December 21, 1967	1300	1.16
	1790-06	" " "	1312	19.18
A-3	8426-03	January 30, 1968	1300	19.18
	8426-04	" " "	1300	1.16
A-4	8426-06	February 1, 1968	1302	0.18**
	8426-08	" " "	1300	1.16
A-5	2780-02	February 5, 1968	1303	0.18
	2780-03	" " "	1308	1.16
A-6	2780-09	February 9, 1968	1331	1.16
	2780-10	" " "	1332	0.18
A-7	6656-01	February 14, 1968	1300	1.16
	6656-03	" " "	1300	19.18
A-8	6654-07	February 16, 1968	1300	0.18
	6456-08	" " "	1305	1.16
A-9	1460-1	February 26, 1968	1300	1.16
	1460-2	" " "	1300	19.18
A-10	1460-02	February 28, 1968	1300	1.16
	1460-03	" " "	1300	19.18
A-11	2105-03	March 5, 1968	1300	1.16
	1454-01	" " "	1300	0.18
A-12	1454-3	March 6, 1968	1300	19.18
	1454-5	" " "	1300	1.16

* Distance between radars (19.18 and 1.16) is 6.22 nautical miles (11,535 meters).

**Distance between radars (1.16 and 0.18) is 15.37 nautical miles (28,499 meters). The TPQ-18(19.18) and TPQ-6 (0.18) are essentially an improved FPS-16 (1.16) [3].

Cape Kennedy, Florida (Continued)

Table	Test No.	Date	Time (GMT)	Radar
A-13	2688-5	March 11, 1968	1317	19.18
	2688-7	" " "	1302	1.16
A-14	2688-8	March 15, 1968	1300	1.16
	2688-1	" " "	1300	19.18
A-15	2626-1	March 19, 1968	1300	1.16
	2626-1	" " "	1300	19.18
A-16	2272-1	March 20, 1968	1300	1.16
	2272-2	" " "	1300	0.18
A-17	2990-1	March 21, 1968	1300	1.16
	2990-1	" " "	1302	0.18

GREEN RIVER, UTAH

Table	Test No.	Date	Time (GMT)	Radar
B-1	10163-01	December 11, 1967	1601	218*
	10163-02	" " "	1601	219
B-2	10164-01	December 12, 1967	1500	218
	10164-02	" " "	1500	219
B-3	10165-01	December 12, 1967	1603	218
	10165-02	" " "	1603	219
B-4	10167-01	December 12, 1967	1804	218
	10167-02	" " "	1804	219
B-5	10168-01	December 12, 1967	1908	218
	10168-02	" " "	1908	219
B-6	10169-01	December 12, 1967	2010	218
	10169-02	" " "	2010	219
B-7	10170-01	December 12, 1967	2113	218
	10170-02	" " "	2113	219
B-8	10171-01	December 12, 1967	2205	218
	10171-02	" " "	2205	219
B-9	10214-01	February 13, 1968	1631	218**
	10214-02	" " "	1630	255
B-10	10216-01	February 13, 1968	1830	218
	10116-02	" " "	1835	255
B-11	10217-01	February 13, 1968	1930	218
	10217-02	" " "	1930	255
B-12	01218-01	February 13, 1968	2035	255
	10218-02	" " "	2030	218

* The distance between FPS-16 radars, 218 and 219, is 153 m.

**The distance between FPS-16 radars, 218 and 255, is 53 m.

PT. MUGU, CALIFORNIA

Test No.	Date	Time (GMT)	Radar
81517-01	March 20, 1968	0127	3001*
81517-02	" " "	0126	3004

*The distance between FPS-16 radars is 207 m.

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APPROVAL TM X-53752

ACCURACY OF WIND DATA OBTAINED BY TRACKING A JIMSPHERE WIND SENSOR SIMULTANEOUSLY WITH TWO FPS-16 RADARS

by Michael Susko and William Vaughan

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

E. D. Geissler
Director, Aero-Astrodynamics Laboratory